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# AN ESSAY

ON

## SOLID METEORS,

AND

## AËROLITES OR METEORIC STONES.

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SCIENCE, &c. &c. &c.

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An object of lofty pursuit, even if it be one of impossible attainment, is not unworthy of philosophic ambition.—BREWSTER.

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## EDITOR'S INTRODUCTION.

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The substance of the following Essay was written for a popular Lecture, and was read by its author before the Academy of Natural Science of Chester County, in the winter of 1841.

Being revised, and having assumed its present form, it was, in 1843, dedicated to "The National Institute for the Promotion of Science." It was referred to three of their most distinguished members, namely, Mr. J. N. Nicollet, Colonel I. I. Abert, and Doctor C. Pickering. This Committee made a report, which will, doubtless, appear among the transactions of the Institution. In the mean time, Mr. Browne has been gratified to find that these learned gentlemen accorded with him in opinion, upon *all the main points* of his discourse.

Upon the general merits of this production, the Committee expressed themselves in these words:

"In conclusion, we take pleasure in stating, that although we have not always concurred in the reasoning and conclusions contained in Mr. Browne's elaborate paper, yet that we have perused it with interest, and not without instruction. A subject so difficult and so doubtful, so vast and so minute, demands for its satisfactory elucidation not only much time and opportunity, but an extent and accuracy of specific knowledge which few men, not *wholly* devoted to science, can be expected to possess. The ingenuity and information displayed by Mr. Browne in his paper, deserve general commendation."

TO THE  
NATIONAL INSTITUTE OF THE UNITED STATES,  
THIS ESSAY

IS RESPECTFULLY INSCRIBED,

BY ITS AUTHOR.

# SOLID METEORS,

AND

# METEORIC STONES.

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FROM the earliest time with which history makes us acquainted, certain dark colored heavy mineral substances have fallen from the heavens. These descents, though numerous, have never failed to excite attention. In ancient times the fallen stones were regarded with the most superstitious awe; many of them (having been converted into idols) were publicly worshipped; and, even in our own times, we peruse with surprise and interest the descriptions of meteoric stones that have fallen in the most distant ages, and in countries the most remote. Their outward appearances are so similar, that the description of *any one* may almost serve for the *general* description of the *whole*; and, what is still more surprising, no sooner had these objects attracted the attention of men of science, and they had been by them subjected to the mineralogical balance and the crucible of the chemist, than it was discovered that they all possessed nearly the same specific gravity, and that all were essentially composed of the same mineralogical materials. In endeavoring to *class* them, and fix their place in cabinets of natural curiosities, it was discovered that in one respect they differed from every other stone found upon the face of the earth.

These important discoveries naturally awakened an anxiety to learn more of their natural history, and led to the inquiry, more particularly, under what circumstances they fell to this earth; and the result of this research was not calculated to allay curiosity, but to excite it to a still higher degree—for it was found that their descents were in some way connected with the apparition of certain *immense meteorological objects*,\* which were contemporaneously seen in the air, under circumstances strange and contradictory—sometimes dark colored and opaque, at others they were luminous in the highest degree. They were almost always of a very great temperature; they generally shed around a prodigious light. Now they were discovered rushing rapidly through the air, when the sky was perfectly serene; or if, perchance, an obtrusive cloud was seen illuminating and beautifying it with various rainbow tints, then they came shrouded in darkness, accompanied with rain, hail, thunder, lightning and tempest. Sometimes they shine “despite the presence of

\* From a quarter to half a mile in diameter.

the resplendent orb of day ;” at others, they, by the comparison, make still darker that awful time—

“ When the dragon womb  
Of Stygian darkness spits her thickest gloom,  
And makes one *blot* of all the air.”

Frequently they have been known to burst asunder with a tremendous noise, causing the air to tremble, and a sensible shock at this earth—and showering down *burning stones* instead of refreshing rain ! What they were—whence they came—what was their awful errand—whither they were winging their rapid flight, who could tell ?

The utmost ingenuity of the most favored intellect has been put to the test—the greatest learning of the brightest ages has been invoked—the talents that discovered the new planets, the perseverance to which we are indebted for a knowledge of the satellites of Jupiter, the exertions of mind which were necessary to calculate the mysterious orbits of the comets, the patience which was endured in observing the transit of Venus—all these were put in requisition. Numerous, indeed, have been the theories, various have been the suppositions that have been made about them ; but whether any one has been fortunate enough to give a satisfactory explanation of these objects, is yet unknown ; for the learned have come to *no decision*, at least upon the question of their origin.

Such being the state of the case, it was deemed that an essay or lecture \* upon the subject would not be unacceptable to an intelligent public ; especially as what has been written upon these meteors is distributed throughout numerous volumes, written in different ages and various languages ; before coming to any conclusion, these have been consulted.†

It may be as well to premise that the word “meteor” is said by some to be derived from a Greek word signifying “*high*,” or “*sublime* ;” by others from two Greek words, signifying “*beyond*,” and “*to lift up*.” It originally comprehended all bodies in the air of a “flux” or “transitory” nature. In some of the old books meteors are divided into æriel, aqueous and igneous. If this division is adhered to, those under discussion will come within the *third* class. But, as “igneous meteors” include also lightning, shooting stars, aurora borealis and ignis fatuus, it becomes necessary to adopt some specific name for those to which we have alluded—for the want of which they have been called “*fæces*,” “*globes*,” “*bolides*,” “*flammæ* ;” and in later times they have been denominated “*fiery meteors*,” “*igneous meteors*,” “*fire-balls*,” “*balls of fire*,” “*flying dragons*,” and “*shooting stars*.” For reasons which will appear hereafter, it is proposed to call them “*SOLID METEORS*.”

The stones which have fallen from these meteors have been called “*ærolites*,” (stones of the air,) “*meteoric stones*,” and “*native iron stones*.”

\* This paper was originally designed as a lecture, and was read as such in 1841, before the Cabinet of Nat. Science of Chester County, Pennsylvania.

† I have a catalogue of 87 of these meteors, and diagrams of 18.

What relates to Solid Meteors, may be studied—

1. In the mathematical laws of their motions ; or,
2. In their physical properties.
3. Their origin.

The first includes their primitive projectile force, their direction, velocity, &c.

The second regards their solidity, their original composition, the chemical and mechanical changes they undergo, with their consequences, &c.

1. First, then, of their *motion* :

Fontenelle remarks, that “when a thing may be in *two ways*, it is almost always in *that one* which at first sight *appears* to be the *least natural*.” Besides which, chained down, as it were, to this sphere, and graduating all our ideas by impressions made upon our minds in childhood, we are prone to consider a *state of rest* to be *the only natural condition of matter* ; and hence, when we perceive any thing in *motion*, we are led to believe that there must have been some immediate and visible existing *cause* for the same. But reflection teaches us that *MOTION* is as *natural as rest*. If we view this earth *as a whole*, it does, indeed, appear to us to be *standing still*, while all the heavenly orbs are circulating around. But with the first step which we take in astronomy, we discover that the earth not only moves around its own axis, but that it is hurried through space with the almost incredible velocity of 1,134\* miles in a minute.

If, as often happens, while we are correcting one error, we incautiously fall into the opposite one, and conceive that the *planets* are motionless, we are soon taught that they are all in motion—that the sun himself (around whom they all circulate) is not at rest ; that the (so called) “fixed stars” are not fixed, but moving—and that the whole system is revolving around some unknown *centre*—perhaps the immutable throne of the GREAT JEHOVAH !

If we transfer our attention to the materials of which the earth is formed, and examine them minutely, here again we shall find that nothing is at rest. Mountains are continually wasting away, and new mountains and new continents are gradually forming in the depths of the present oceans. If the sea were stagnant it would be corrupted with the vast quantities of remains of animals and vegetables with which it abounds ; but *it*, too, is in perpetual agitation.

The atmosphere is unstable—immense bodies of it, rising from the heated tropics, roll down the inclined planes toward the poles—and thence advance forever toward the tropics again. Beside which, the air has numerous subordinate movements, owing to general and local causes.

Aqueous vapors, borne upon the everlasting wings of the air, pursue their ceaseless courses to the upper regions, where they are condensed and precipitated to the earth again, only to furnish fresh matter for future exhalations and exaltations.

If we ascend in nature’s scale from inorganic to organic matter, whether of vegetable or animal life, still all is *motion*. The germination of seeds, the ascension of the sap of plants, the separation of

\* Herschel.

the more precious juices from the grosser fluids, the constant and wonderful changes of roots, stems, branches, leaves, flowers and seeds again, (to which change we are indebted for the foliage, the umbrage, the verdure, the fragrance, and the flavor of the vegetable world,) are nothing but a *round of vegetable motions*.

So with *animal life*, it is motion without end. So indispensable, indeed, is motion, voluntary and involuntary, in *this* department of nature, that by some persons *life and motion* have been considered one and the same. Even when comparatively most at rest, in sleep, our respiration, the circulation of the blood, our digestion, and numerous secretions are silently but continually going on; and although poets have sung of "the stillness of death," *that*, in reality, is only a *change* of motion, and not its cessation; for no sooner is the motion of vitality extinguished, than a new set of movements commence, which never cease until the subject is entirely decomposed.

There can be no *sound* without motion; no *heat* without motion; no *light* without motion; no *gravity* without motion; and what are electricity and magnetism but the *motions* of an unknown fluid? We can look neither upon ourselves nor abroad without beholding a system of perpetual fluctuation. The *materials* with which nature operates are, it is true, beautifully few, simple, and permanent; but she toils incessantly to form, demolish and build up anew her stupendous works; hence that endless variety of forms and colors which delight the eye of the naturalist.

In beholding solid meteors then, in *motion*, so far from there being any thing *unnatural*, it would be much more astonishing to observe one, in the air, *at rest*.

As for the *cause* of the motion of solid meteors, astronomers account for the *motions of the planets only*, when you grant them a *previous uniform projectile force*. Without this concession the Copernican system falls to the ground; for it is based upon the principle that matter is, of itself, inactive, and indifferent to motion or rest; that is to say, that it possesses no *inherent* power to move itself nor to put itself to rest.

Newton *supposed* that, at the creation, each planet was impelled by a single stroke, such as would, of itself, compel it to move at some uniform rate and in a straight line forever; the *direction* being perpendicular to the sun's attraction.

Now supposing solid meteors, like the planets, to have been impressed with an initial motion, the next step would be to ascertain their *directions*.

At first, while in free space and uncontrolled by *any external* force, a *straight line* is the only path they could pursue. And this would be the case whether there exists or not an ethereal medium beyond our atmosphere; since, it is evident, that such a gas, however it might retard the progress of a solid meteor, would have no power to turn it to the right or to the left; but it would be allowed to continue its endless course in the same plane, and in the infinitude of boundless space.\*

\* Arago Comet, p. 30.

But very different would be the case as soon as a solid meteor came within the sphere of attraction of the sun or any other body.

"A comet (says Arago) passing near a planet has its course so much deranged, that the course described afterwards can in no manner be considered as a continuation of the *natural* course previously described."\*

The same would be the case with solid meteors, taking into the account, however, the difference in velocity.

Of the numerous reports of solid meteors to be found in the books very few indeed have been observed, from two stations, with that attention required to ascertain their directions. But these tend to show that solid meteors are of cosmical origin.

1. The meteor which appeared on the 26th November, 1758, in England, Ireland, and Scotland. At Cambridge its path was vertical, or nearly so; it proceeded north and by north to Inverness, a course of 400 miles, when it disappeared.

2. The one which was seen by Cavallo, in England, the 18th August, 1783. Its distance was 130 miles. Length of path 550 miles; height  $56\frac{1}{2}$  miles; duration  $\frac{1}{2}$  a minute. It came out of the horizon of Paris in the north a little west, and entered it again south a little east. Duration 15 or 20 seconds. Baron de Berestaoff, of Gottingen, calculated its force equal to the gravity of a body through 50 leagues of height; its initial velocity 1052 toises per second; its greatest elevation 5725 toises or  $2\frac{1}{2}$  leagues above the cloud from which it rose; its elevation from the horizon of Paris  $1518\frac{4}{5}$  toises; its real diameter 216 feet. But he adds that all these calculations are below the truth.

Mr. Dalton says its height was about 60 miles.

3. The meteor seen in Ohio, the 18th May, 1838. Its perpendicular elevation was  $28\frac{5}{8}$  miles. It was seen in the zenith in lat.  $41^{\circ} 16'$  long. 1 west of Washington. At its explosion in lat.  $44^{\circ} 7'$  long. 2 W. Its height was 32.1 miles; length of path 218 miles; mean course north  $13, \frac{1}{2}$  west; curvature 6 miles.†

The sudden appearance and short duration of solid meteors are the reasons why there are so few accurate reports.

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## OF THE VELOCITY OF SOLID METEORS.

From the calculations and statements made by eminent philosophers and astronomers, there are three degrees of velocity which, in regard to solid meteors, it is necessary to notice, viz.

1st. If the velocity of a solid meteor, which comes within the sphere of attraction of this earth is less than 300 miles in a minute, it must fall to this earth by the power of their mutual attraction.

2d. If the velocity of a solid meteor is more than 300 miles a minute, and less than 430 miles in a minute, it must revolve around the earth.

3d. If the velocity of a solid meteor is more than 430 miles a mi-

\* Arago Comet, p. 13.

† Loomis.

nute, it must overcome entirely the attraction of the earth, and it will be carried off in curves of a hyperbole.\*

Now as it is well known that the main body of a solid meteor never has fallen to this earth, and as we have no reason for believing that any one has ever revolved around it, since no one has ever pretended to identify the same solid meteor paying us a second visit, it would seem, *a priori*, that they possess a velocity of more than 430 miles in a minute.

But the rapidity of the movements of these bodies deserves a little more of our attention. As the rate at which solid meteors move is a feature of the greatest importance, in their natural history, it is to be regretted that upon *it* more attention has not been bestowed. Of the numerous cases that have come under our examination, the rate at which they move has been mentioned in *five* only. And this fact is the more remarkable as a majority of the reports have been drawn up by men of letters. In the case of the solid meteors seen by Professor Baudin, of Pau, in 1790, the terms made use of are "with very great velocity." And Professors Silliman and Kinsley in their account of the one seen at Weston, Connecticut, in 1807,† first say that it passed "with great velocity;" and afterwards that "its progress was not as rapid as common meteors and shooting stars." It will be perceived that very little information as to the *rate* is to be gleaned from these two cases; so that our five are reduced to the three cases that follow.

The solid meteor seen in England in 1758,‡ whose velocity was calculated by Sir John Pringle as 30 miles in a second, or 1800 miles in a minute, &c.

The one seen in England in 1783 by the learned Cavallo, who supposed it to have travelled 1000 miles in half a minute.

And the one seen in Ohio in 1838.§ Professor Loomis has given the latitudes and longitudes of the place where it was first seen in the zenith, and of the place of its explosion—and its courses—from which he calculated the length of its path to have been 218 miles, and upon comparing these with the time that it was visible, this learned gentleman calculated its velocity to have been 30 miles in a second, or 1800 miles in a minute.

This last case is entitled, by the apparent correctness in this particular, to be considered as the leading one; now, considering it as such, and taking the two preceding ones as corroborative, there is sufficient evidence for the admission, that solid meteors have a velocity of about 1800 miles in a minute.

To this it has been objected, that an object passing with that velocity through the air could not be discerned; but Mr. Wheatstone, professor of natural philosophy in King's College, London, has recently ascertained, that an electric spark which the eye is capable of distinctly perceiving, has a duration of only the millionth part of a second.|| This difficulty having been surmounted, we will endeavor

\* The Rev. Thomas Clapp, President of Yale College, in an Essay entitled "Conjectures on the Origin and Motion of Meteors," and see 2d Henry's Chemistry, p. 407.

† Mem. of Con. Ac. 1 v. 141. ‡ Phil. Trans. v. 41, 218. § Silliman's Jour. v. 35, p.

|| Phil. Trans. for 1834, p. 2.

to obtain some notion of the velocity of solid meteors by comparison with other bodies.

		Miles in a Minute.
The velocity of the wind during the greatest hurricane ever known		
was less than	(Cavallo)	2
The velocity of sound is	(Cavallo)	12
Saturn in his orbit has a velocity of	(Ferguson)	300
Jupiter	"	416
Uranus	"	753
The Earth	(1131—Herschel)	1140
Venus	(1336—Herschel)	1300
Mercury	(1823—Herschel)	1583
Solid Meteors	(Pringle, Cavallo, Loomis)	1800
The Comet seen in 1680		14,666
The tail was emitted in one minute		20,833
Light	(11,520,000—Herschel)	9,840,000
The Electric Spark	(Wheatstone)	17,280,000

From the above table it would seem that Doctor Blangden was mistaken in supposing that these meteors exceed in velocity every other object known, except electricity; for the comet of 1680 moved with 8 times their velocity, and light moves with 546 times the velocity of solid meteors.

To avoid error it is here necessary to notice that Cavallo, in describing the solid meteor of 1783, says, that when it was first discovered, "it was almost stationary;" a statement so difficult to reconcile with the rapid progress of its movement immediately afterwards, that we are warned that there is unintentional error somewhere; and the fact is, that this *apparent* state of almost rest was an optical deception, as can easily be shown. The meteor must have been *then* seen moving in a line directly towards the observer. A bright object, seen at a distance, moving directly towards the eye, always appears to be stationary, except that it increases in brilliancy. So if it is receding directly from the eye, it appears to be stationary, except that it diminishes in brilliancy. Now the former was the case with this meteor seen by Cavallo, for that learned gentleman tells us that "it increased gradually in light." If any thing further were necessary for this explanation, we have it in the fact which is next stated by this observer, viz., that the first motion he thereafter perceived was "its ascending above the horizon," that is to say, it was deviating from its direct course towards the eye, which it had previously maintained.

Ferguson, the astronomer, warns his readers against such optical deceptions. "Some of the planets," he says, "appear to go backwards, and others to stand still; but these are known to be optical deceptions."

To make "assurance doubly sure," we will, before we take leave of this point, add, that if the meteor was at rest when Cavallo first saw it, there is no possibility of accounting for the prodigious velocity which it was immediately afterwards known to have had. On the contrary, it would have fallen in a direct line to this earth in obedience to the universal law of gravity; but this it did not do.

Now, if solid meteors have a velocity of 1800 miles in a minute, as we think we have proved, then, according to the three laws of progression above quoted, they can neither fall to this earth by the force of mutual gravitation, nor revolve around it by virtue of the

combined forces of their initial motion and gravitation; but they must continue their courses respectively, varied a little by the earth's attraction; and this solution in theory agrees with our experience, so far as solid meteors have been noticed and described.

If the foregoing is, as we believe it to be, a correct view of these objects, then they cannot be *terrestrial comets*, as thought to be by Professors Clapp, and Day, and Cavallo.

2dly. Of their physical characters; and 1st, of their *Solidity*.

Whatever may have been the opinions anciently entertained in regard to these meteors being of a *gaseous nature*, they are now almost universally acknowledged to be *Solids*. There is a body of evidence, consistent in all its parts, emanating from numerous eye-witnesses, living in different countries and ages, persons of known integrity and of sufficient skill and knowledge to guide the judgment, that aërolites of the consistency of iron, nickel, silex, &c., have fallen directly from these meteors; and which, of course, must antecedently have been component parts thereof. Many of these meteoric stones have been collected while still hot—they are to be found in almost every Museum of Natural History, have been examined here and in Europe, and analyzed by chemists, and have been found wonderfully to agree among themselves in character, while in one respect they differ from all other minerals. Upon this solid basis of human testimony the learned have pronounced, that aërolites, and the meteors from which they are ejected, are *Solids*. We do not, therefore, consider *this* point any longer questionable; nor, unless some new facts can be produced, open for argument. It is what the schoolmen term a "*probatum est*," and hence we have taken the liberty to call them "*SOLID METEORS*."

It is true that Professor Loomis thought that the meteor seen by him in Ohio, in 1838, was "exceedingly rare and of feeble cohesion"—"resembling," as he says, "*atmospheric air*." But we respectfully submit that the facts upon which he says he founds this opinion are altogether insufficient to warrant his conclusions.

He says that "during nearly its entire course (which he computes at 218 miles) new portions of matter were continually detaching themselves from the main body, and that *this* finally divided itself into a large number of fragments."

But similar appearances of division, and also of partial and general explosion, have been noticed in other cases of meteors, from which aërolites of the densities of iron, nickel, silex, &c., have been seen to fall.

Professor Baudin, in describing the meteor he saw near Pau, calls it "a fire ball;" it was of a larger diameter than the moon, had a tail 5 or 6 times the length of its own diameter, it divided itself into several portions, several fragments were found; one weighed 18 lbs. and had sunk three feet into the earth—it was a stone, black outside and gray within, with shining particles, and gave sparks with steel.

As to Professor Loomis' meteor resembling "*atmospheric air*," how is it *possible* that a body could be carried through a *medium of its own density* for 218 miles, with a velocity of 1800 miles in a minute?

But the professor continues, "The meteor seen by him," he says, "was *entirely consumed* in ten seconds." Now in this opinion, also, we believe this learned gentleman was entirely mistaken.

In the case of the meteor seen in 1758, in England, Ireland and Scotland, Sir John Pringle collected a large body of evidence from persons who had seen it from 21 different stations, from which it appears that these objects assume a variety of phases; some not easily reconcilable with others of a *later* period. This meteor, at Manchester, appeared like a ball of fire with a train of light, which soon collected into the body and then burst, stars falling down from a part, and the rest *vanished*—yet at the next station, Liverpool, it was seen again, a *moving* ball of fire.

There are no less than four cases on record where the main body of the meteor bore the appearance of a *cloud*, but from all of which *aërolites* of the densities aforesaid were ejected. In another case, it was "a great fire," and in another still, had the appearance of a "*blaze of light*." We have no doubt but that solid *aërolites* were cast from the meteor seen by Professor Loomis, but such was the unsettled state of the country over which it passed that none have been yet discovered.

Without, therefore, pretending to call in question the *facts* stated by Professor Loomis, we respectfully submit that he has not weakened the evidence of the *solidity* of these meteors by the hasty opinion he formed of the one seen and described by him. They must still be considered as *solids*; and if so, then there is an end to the theory of Sir Isaac Newton, viz. that they originate in the tails of comets, provided those appendages are as light and gaseous as astronomers seem to consider them to be, and as the perception of a star through them would appear to warrant. It is also fatal to the opinion of Halley, who imagined that these meteors were trains of inflammable vapor suddenly ignited; and no less so to the supposition of Luke Howard that they are hydrogen gas. The solidity of these meteors also goes a great way to confute the supposition that they are generated in our atmosphere.

#### IV. Their *original* composition.

We believe that *solid meteors, when they enter our atmosphere, are composed of the native metals and the metallic bases of the earths and alkalies.*

This opinion is based upon the following considerations:—

1st. The two metals that are always found in *aërolites*, viz. iron and nickel, the former of which is in great abundance, are, in part, detected therein *in the native state*; yet native iron and native nickel are of *very rare occurrence*; the former so much so, that it is still a question, among mineralogists, whether it *ever* occurs, except in *aërolites*.\*

2d. From Analogy. Sir Humphrey Davy, Professor Hare, and others, have, through the agency of the galvanic battery, shown that the earths and alkalies, (which were formerly considered as elementary bodies,) are compounded of *metallic bases*, combined with

oxygen. So that the immense masses of matter, of which the crust or rind of this earth is chiefly made up, are in fact oxides. That the materials of which this crust is composed were once in their elementary state of the metallic bases and of the native metals, and that they owe their changes and present forms to a combination with the oxygen of the air and of the aqueous vapor contained in the atmosphere, is highly probable; and, reasoning from analogy, we venture to presume that solid meteors, before they enter our atmosphere, are composed of the metallic bases of the earths and alkalies, and of the native metals, uncombined with oxygen.

If the *crust* of the earth is now in a state of oxide, it is probable that the *interior* of it, (which is protected from the operation of the oxygen of the air,) is composed of the metallic bases of the earths and alkalies and the native metals; a theory which accounts for the greater specific gravity of the interior than the crust, which explains the magnetic meridian of the earth, and which assigns a reason for the dip of the needle. And the occasional transformation of a portion of the interior into oxides, by absorbing oxygen, from the water which percolates through the crust of the earth, accounts for, in part, earthquakes and volcanoes.

3d. The supposition that solid meteors are originally composed of the metallic bases of the earths and alkalies and of the native metals, will account, in a natural manner, for their *spontaneous combustion*, when they are introduced into our atmosphere,—the exceedingly *high degree of temperature* which many of them possess, and their *explosions*; phenomena which hitherto have remained entirely unexplained.

The idea so generally prevalent that solid meteors, being originally cold, acquire their heat by passing rapidly through the atmosphere, that is, by the friction of the air, is singularly erroneous; since (as it is presumed,) that not only is their rapid passage insufficient to account for that result, but it would lead to one directly contrary! What mechanic ever heard of heating a cold bar of iron by rapidly whirling it through the air? On the contrary, if a bar of iron, moderately heated by artificial means, is whirled with rapidity through the air, it would be much sooner cooled than if the bar was left at rest: for this simple reason, the heated bar is cooled by changing caloric with the air or any thing else with which it comes in contact, that is of a temperature lower than itself. Now it is certain that the bar, when whirled in the air, comes, successively, in contact with a much larger portion of air than if it had been left at rest. In like manner one of us, when heated, will be much sooner cooled by remaining in a current of air than by being in a calm. Every child knows that by the act of fanning they remove from their immediate vicinity the air which has been heated by changing caloric with the person, leaving room for a fresh supply of cool air which rushes into the vacancy produced.

In answer to the above reasoning it has been said that if a bar of iron be artificially raised to a white heat, and it is then whirled rapidly through the air, that it will exhibit a much more vivid appearance than when such a bar is left at rest. But this is accounted for

by the circumstance that this bar, having had its temperature raised, artificially, to that degree which enables it to absorb oxygen with readiness, it must necessarily increase in vividness of appearance in proportion to the supply of oxygen to be absorbed. And this increase of supply is effected by the rapid motion in the air; for it removes the bar continually from the vicinity of that portion of the air which the bar has deoxygenated, into the vicinity of other portions of atmosphere which have not been deprived of their oxygen. But that this is not a case in point is apparent, since the question under present examination is not whether a solid meteor, *already ignited* to a great degree, can be urged to a still further degree of heat by a more abundant supply of oxygen; but the question is, whether solid meteors, *being cold*, can, by a rapid passage through the atmosphere, be heated by the friction of the air.\*

Sir Isaac Newton made some calculations to show the time which the comet of 1680, (which had a velocity 14,666 miles in a minute, which is 8 times that of solid meteors,) would take in *cooling* by its rapid passage through the air,—which shows, that it never entered into the mind of this distinguished astronomer to conceive that a meteor by its rapid passage through the air could be *heated*.

Count Rumford, who has given to the world an account of various interesting experiments upon exciting caloric by friction, has never suggested the idea of using any thing but solids against solids. And Mons. Picket states, affirmatively, that *solids alone* produce heat by friction.

It is true that Doctor Alexander, in his experimental essays, informs us, that by blowing with a pair of hand-bellows upon the bulb of a thermometer it was heated one degree. But we take the reason to be this,—the air and vapor in the hand-bellows is *condensed* by the act of blowing; and so is the caloric which is contained in them: which (condensed caloric) being precipitated upon the bulb of the thermometer would naturally raise its temperature in the small degree that has been noticed.

It has never been asserted by any experimenter, that *non-compressed* air would *raise* the mercury in the thermometer, upon being brought in contact with the bulb, except in the way of exchanging caloric. On the contrary, Professor Leslie found, after many experiments, that the *loss of heat* which a moving body sustains in its passage through the atmosphere is proportional to the extent of space which it describes; and that the refrigerating power of a current of air acting upon a *stationary* body, is exactly proportionate to its velocity. And upon these principles he constructed an ANEMOMETER, an instrument for measuring the velocity of winds by the *falling* of the mercury in the thermometer.

Now is not all this strangely at variance with the idea that solid meteors, being cold, are heated to a violent degree by passing rapidly through the atmosphere?

Friction is defined to be “the resistance opposed to the motion of

\* The above suggestions explain a *paradox* in the history of solid meteors and aërolites, viz. that the same air which urges the already heated solid meteor to a state of more perfect incandescence, cools the aërolites during their passage to this earth!

a body." If so it must be in exact proportion to its weight or pressure.

Now at the surface of this earth each square inch of atmosphere weighs 15 lbs.; the friction of the atmosphere at the earth's surface would then be 15 lbs. for every square inch of pressure upon a solid meteor there found. But it is well known that this weight or pressure of the atmosphere diminishes gradually as you ascend in the air: At the height of 18,000 feet, which is only a little above the height of ordinary clouds, the friction would be only  $7\frac{1}{2}$  pounds to the square inch; this was the height at which was seen the solid meteor at Sienna in 1794. At the height of seven miles the pressure is only 3 lbs. 12 oz. per square inch; the solid meteor seen at Pau in 1790 was a half mile higher than this point. At the height of 28 miles the pressure would be less than 1 oz. for every square foot; and there the solid meteor was seen in Ohio in 1838. At the height of 38 miles where the solid meteor was seen that passed over Dalmatia in 1676, the pressure is only 41 grains for every square inch. And at the height of 60 miles, which according to Dalton was the altitude of the solid meteor seen in England in 1783, the friction is less than one grain for every square inch.

Now what has become of this enormous *friction* which is to account for the heating of solid meteors?

The advocates for the theory we are examining answer that it is to be found in the *velocity* of the solid meteors, which, they contend, is so very great that it makes up for the want of *pressure* or *weight* in the air.

But Messrs. Amanton and Euler agree in opinion that, for the most part, friction is *not increased* by velocity; and Coulomb even goes so far as to assert that, in some cases, friction is *diminished* by velocity.

Besides which it might be urged, if necessary, that solid meteors are not *dragged*, but *roll* through the air, and it is a law of friction, that it is much less in a *rolling body* than it is with one that is *dragged* along\*.

To which might be added, that the friction of *heterogeneous* bodies, such as a solid meteor and the air, is less than between *homogeneous* bodies. And that when a body is already in motion, (as solid meteors are when they enter our atmosphere,) there is only one half the friction that there would be to set them in motion.†

It would seem then upon principle, no less than upon authority, that the friction of the atmosphere (as it is called) is altogether inadequate to the task of generating the enormous heat at which solid meteors are known to arrive as they pass through the air.

It may perhaps have excited surprise that so much time and labor have been bestowed upon this portion of the subject; but it should be recollected that the position we have been combating is supported by *great names*.‡ And that while we prefer the TRUTH to names

\* See the Abbe Nollet and Bossuet.

† Vince.

‡ It is material to notice that the *opinion* we have been examining has nothing to do with the *condensation* of the atmosphere, but only the *friction* of the same.

Professor Clap, in his "Conjectures on the Nature and Origin of Meteors," says, that by

however exalted, we hold that even the *errors* of the learned should be treated with becoming respect. Nothing (says Locke) is so beautiful to the eye, as *truth* is to the *mind*, and it is *that* of which we are in search.

Another favorite method of accounting for the prodigious heat of solid meteors is by *electricity*.

Upon this opinion we will proceed to submit a few words. For the purpose of this investigation, it is not necessary to inquire whether solid meteors were *originally* electric; since, when they were in free space, the electricity, if any they ever had, must have been entirely dissipated: for it is a law of electricity, that that "substance" or "property of matter," (which ever it may be,) exists entirely upon the exterior surface of bodies; where it is confined by the pressure of the atmosphere. It is then assumed, that solid meteors, when they enter our atmosphere, are *non-electric*.

Now although the atmosphere of this earth is a *non-conductor* of electricity, yet it is admitted, that it sustains an aqueous vapor which is impregnated with electricity. The ordinary attitude of this vapor is from one to three miles, and never exceeds ten miles.\*

It is also admitted that aqueous vapor possesses the power of *communicating* electricity to bodies passing through it; for it is another law of electricity that a solid rubbing against a liquid or a gas excites electricity.

But the *kind* of electricity depends upon the state of the atmosphere. When that is pure the aqueous vapor is in a constant state of *vitreous* electricity; but clouds would effect this state, and, *a fortiori*, so would great disturbances in the atmosphere, such as strong winds, rain, hail, snow or tempests.

Now let us endeavor to apply these acknowledged principles to the question under consideration.

1st. A solid meteor enters, non-electric, into our atmosphere, and while it is still *above* the region of aqueous vapor, and of course in that portion of the atmosphere which is a *non-conductor*, it spontaneously takes fire. How can this be ascribed to electricity? It is a natural impossibility.

Now these were the cases of the meteor seen in England in 1783, which was 60 miles high—the one which passed over Italy in 1676, which was 38 miles high—the one seen in England in 1758, which, in its lowest altitude, was 29 miles high—and the one seen in Ohio, in 1838, which was 28 miles high.

But, secondly. Suppose a solid meteor to descend into the region of aqueous vapor; if the sky is clear and serene, (as was the case in

*the friction of the air* they are heated. Cavallo, in his Natural Philosophy, page 768, says, "When this body (a meteor) comes within a certain part, however rare, of the atmosphere, with its immense velocity, the *friction* it suffers may possibly heat it to a degree of incandescence," &c. And again, "The heat which the body acquires in consequence of *friction* produces two natural effects," &c.

Professor Chaladni says, "By their exceeding great velocity, still increased by the attraction of the earth and the *violent friction of the atmosphere*, a strong electricity and *heat* must necessarily be excited," &c. London Phil. Mag. vol. 2, p. 1. It is *said* that Rittenhouse and Franklin favored this theory.

\* Herschel.

20 out of 27 of the cases reported where the state of the weather is mentioned,) what would be the consequence?

A non-electric solid meteor enters into a medium which is charged with vitreous electricity only. How can there be combustion? In order to effect that object, there must be the presence of *both vitreous* and *resinous* electricities—and a communication must be effected between them. If, then, *one* kind only is present, how can it be so confidently asserted that the combustion of solid meteors is attributable to electricity?

Besides which, it has been ascertained that *light* is not a constituent part of electricity, nor even a constant attendant upon electric phenomena, when the electric fluid passes freely through a good conductor, *no light* is produced. It is only when the electricity is discharged in considerable quantities, and passes into or through a resisting medium, causing a sudden compression of the air—that the light, which is in the atmosphere, not in the electricity, is squeezed out of the atmosphere, and makes its appearance.

Now, this being the case, it follows that the light emitted should vary in degrees of brightness in exact proportion to the *density* or *rarity* of the air through which the electricity passes; and the experiments of Sir Humphrey Davy, made in condensed air, and with the Torricellian vacuum, have confirmed this position in the most satisfactory manner.\*

Then applying these principles to solid meteors, if “their incandescent appearance is entirely electrical, and there is nothing of combustion in the phenomenon,” (quoting, as we do, the very words of Dalton,) how comes it that their illuminated appearances do not correspond, respectively, with their respective altitudes? As we know that this is not the case, we may safely affirm that their *light* does not depend upon electricity any more than their *heat*.

Having examined the two popular theories for accounting for the great heat and incandescent appearance of solid meteors, and (if we may be permitted to adopt the expression) “opened the field of discussion for a new location,” we will proceed to inquire what further ground there is for believing that these objects are originally composed of the native metals, and the bases of the earths and alkalies—and that their spontaneous combustion is, as we believe, caused by these materials absorbing oxygen from the atmosphere.

Upon a solid meteor, composed of the materials we have supposed, entering that part of our atmosphere which is dense enough to support combustion, and which, according to Herschel, must be within 80 miles of this earth, it would absorb oxygen from the air—which, it will be recollected, contains 21 per cent. of this gas. This absorption of oxygen, or combustion, (for ordinary combustion or burning, is nothing but a rapid oxydation; or, to use the language of science, “a chemical union with oxygen, with intensity of action,”) would change the materials of the crust first, transforming them into oxides, at the same time evolving caloric and light in high degrees; and this corresponds with the appearance of solid meteors.

\* Phil. Trans. 1832, and Thomp. Outlines, p. 470.

Let it be recollected that inflammable bodies derive their power of *burning* with less difficulty than those that are not inflammable, entirely to their great affinity for oxygen, at the ordinary temperature of this earth; and such is the affinity of the metallic bases of the earths and alkalies for oxygen, that when artificially made they cannot be preserved at the ordinary temperature of this earth but for a very short space of time, unless they are placed under naphtha, to preserve them from the oxygen of the air. Potassium, which is one of them, fuses at  $150^{\circ}$  of  $F^{\circ}$ , and when cast upon water, will burn intensely, instantly extracting oxygen from the water.

Speaking of the metallic base of lime, Sir Humphrey Davey says, 'In the case in which I was enabled to distil the mercury from it to the greatest extent, the tube unfortunately broke, while warm, and, at the *same moment, when the air entered*, the metal *took fire*, and *burnt into quick lime*, with an intense white light.'\*

At about  $800^{\circ}$   $F^{\circ}$  almost all mineral substances become "red hot." At  $180^{\circ}$   $W^{\circ}$ , cast iron becomes "white hot," and fuses; but there is a temperature of a still higher degree, at which iron burns in oxygen, throwing from it most brilliant rays of white light.

Now solid meteors have been seen, both in the day and in the night time, passing through all these colors—from the dark colored or black of the cold iron, to the intense white at which that metal burns, precisely as would be expected should a solid meteor enter our atmosphere, composed of the materials which we have supposed, and after taking fire, pass gradually into air denser and more dense, as it approaches the earth.

Besides which, the *aërolites* which have been seen to fall from these solid meteors, some of which have been gathered while yet hot, have the appearance of having undergone this heating operation; some are covered with a coating of iron, which appears to have been fused; and, in one case, viz: that described by Mons. Arcet, in 1790, the substance of the *aërolite*, when found upon the earth, was in a half melted state.

It is no objection to this explanation that sulphur is found in *aërolites*, for sulphur has an astonishing tendency to unite with metals; and the proto-sulphurets are capable of supporting an intense heat without decomposing. Indeed, it is doubtful whether *all* the sulphur *can* be driven out of iron—for Mr. West, upon experimenting, recently, upon English bar-iron of the very best quality, with muriatic acid, detected sulphur therein.

Nor is it any answer to say that the inflammation *may* have been entirely caused by the burning of *gases*, as contended for by Mr. Halley, Mr. Howard, and others, since all those who have had any experience upon the subject know, that the light emitted by the combustion of mere gaseous matters is pale and feeble, when compared with the burning of *solids*. Pure hydrogen gas burns with a *pale blue light*, but iron filings cast into it will increase the heat and light in an eminent degree.

Allow us to refer to some of the reports of solid meteors. In the

\* Trans. R. S. p. 2 Nich. Jour., v. 21, for 1838.

description of the one seen in England, in 1719, it is said—"Its color was whitish, and of a vivid dazzling lustre, which seemed to surpass that of the sun."

The one seen in England in 1758, had often "a brightness equal or nearly equal to sunshine."

The one seen at Bridgewater, Mass., in 1759, was "so bright as to cast a shade, though the sun was shining."

Cavallo describes the light of the one seen by him, in 1783, "as *prodigious*. The whole face of the country was illuminated."

Montauli describes the clouds around the one seen by him, in 1794, to have been "like the basin of a fiery furnace."

The one seen at Cambridge, England, in 1817, was "*bright*, though occurring in broad daylight, and opposed to the sun's orb, which was at the time shining with splendor in a cloudless sky."

Now it is respectfully submitted, that these extreme degrees of light, witnessed by so many experienced eyes, and so graphically described, does not lead to the opinion that they proceeded from the burning of *gases*, but upholds us in the belief that they were caused by the union of the metallic bases of the earths and alkalies, and the native metals with oxygen.

The *rapidity* with which solid meteors pass through the various gradations of temperature, from the moment they begin to absorb oxygen until they arrive at the highest state of incandescence of which they are capable, is another and a strong proof of their original composition. A few seconds is the longest time that these objects have ever been seen; and it is not easy to conceive of any method whereby such large masses of metals, and other mineral substances, could be heated in such a very high degree, in such a short space of time, except by the rapid absorption of oxygen, by the metallic bases of the earths and alkalies, as has been above supposed.

A ton of pig iron, in a puddle furnace, with all the advantages of fuel of the first quality—say four hundred weight of anthracite, and a current of hot air, cannot be fused in less time than one hour and a half. The reasons are these: The anthracite is a body which, at the ordinary temperature of the air at this earth, will not combine with oxygen; it must be *ignited*—that is to say, its temperature must be raised, by bringing it in contact with something else which is either more inflammable, or whose temperature has been previously raised. When the heat is raised to a certain degree, the anthracite absorbs oxygen, or begins to burn; the elevation of temperature consequent upon this combustion, facilitates the operation and increases the heat, by thenceforth absorbing oxygen more rapidly. When the heat arrives at 800° of F., the anthracite becomes "*red hot*" upon the surface, but all this while the *mass* of the fuel remains solid, its outward particles being gradually lifted away by the oxygen acting at the surface only. In the mean time, the caloric of the oxygen, set free by its union with the anthracite, is acting upon the iron in its vicinity, until *it*, too, is raised in temperature to that point when the attraction for the oxygen overcomes the power of the attraction of the atoms of the iron for each other, when the iron fuses.

Now it will be perceived that all this requires *time*—a *great deal of time*—and we thence learn that the materials of which solid meteors are originally composed, when they enter our atmosphere, could not have been in the *same state* in which they are found in the *aërolites*; since, *in that state*, they could not have been brought to so high a degree of heat, and such an appearance of complete incandescence in a few seconds—which, as aforesaid, is the longest time expended in passing through all their changes.

But, if we adopt the explanation herein given, viz. that solid meteors, when they enter our atmosphere, are composed of the metallic bases of the earths and alkalies, and that they become heated by uniting with oxygen, the whole mystery is solved; for we know, from the experiments above referred to of Sir Humphrey Davy, that this union is *instantaneous*, and the *combustion intense*.

This explanation has also this decided advantage over any other that has ever been offered to the public, viz. it accounts for the paucity of mineral substances found in *aërolites*, compared with the number of them that are found upon the surface, or in the bowels of this earth; and also in explaining why, in some other cases of minerals being detected in them, they are found in such small quantities. When solid meteors enter our atmosphere they may, and very probably do, contain the bases of many minerals not found in the *aërolites*, which, it must be recollected, are cast from these meteors *after* they have been heated to an intense degree; and when, therefore, many substances originally solid in them may have been fused, volatilized, and have passed off. But, it may be asked, if solid meteors contained, originally, the metallic bases of other mineral substances, not usually detected in *aërolites*, is it not probable that the able chemists who have been employed in analyzing them, would have found at least a *trace* of other minerals therein? We answer that *it is* probable, and we find that the learned and indefatigable Berzelius found in four of these meteoric stones, which were subjected to the most rigid scrutiny, *traces* of cobalt, tin, copper, phosphorus, potash and soda.\* (Jour. de Pharm., Feb. 1837.)

Professor Apjohn found in a stone which fell at Adair, Ireland, cobalt, chrome, magnesia, and lime in small quantities.

Perhaps the burning of these minerals may account for the variety of *colors* sometimes observed in solid meteors. The one seen in Edinburg, in 1826, is described as having a tail of beautifully variegated colors; and we know that soda gives out a *yellow* when burning, potash a pale violet, lime a brick red, strontia a bright crimson, lithia red, barytes a pale apple green, and copper a bluish green color.

And lastly, in support of our position in regard to the original composition of solid meteors, might we not be permitted to add, the well known frugality of nature in all her operations, and the beautiful simplicity of all her laws, she never employing more agents when *one* is competent to perform the task,

\* The first of these fell in Blanski, Moravia; the second in Chantamay, in La Vendée; the third at Lontaloux, in Finland; and the fourth was found by Pallas, in Siberia.

V. Their chemical and mechanical changes, and variety of forms; explosions, and the ejection of aërolites.

All the various forms that solid meteors present to the eye may be caused by *heat*; and that heat may be caused by the absorption of oxygen by the metallic bases of the earths and alkalies and the native metals.

The following are the changes produced, consecutively, upon a solid by heat:—

1st. Increase in size of the mass. 2d. Softening. 3d. Melting or fusing, i. e. becoming liquid. 4th. Burning, i. e. becoming a gas.

1st. Increase of size. This would be caused in two ways. 1st, by the expansion of the material. Iron raised to the heat of boiling water, (according to Arnot,) expanding  $\frac{1}{27}$  part of its bulk. 2d, by the addition of oxygen.

Taking the mean analysis of 8 aërolites, it gave of oxide of iron  $37\frac{1}{2}$ , silex  $53\frac{1}{2}$ , magnesia  $17\frac{1}{4}$ , nickel 2.

Now if the solid meteors from which these aërolites were ejected, entered our atmosphere with the *bases* only of these minerals, they must have received from the atmosphere an accession of oxygen, as follows, viz.—

The native iron,	24 $\frac{1}{2}$	must have absorbed	12 $\frac{1}{2}$	of oxygen.
The bases of silex,	27	“ “	25	“
Magnesia,	14	“ “	2 $\frac{3}{4}$	“
The nickel,	1 $\frac{3}{4}$	“ “	$\frac{1}{4}$	“

This explains what is said in the report of the solid meteor seen in England in 1758, viz. that “it *increased in size*,” before it burst.

2d. Softening. This explains the variety of changes in shape, at first globular, then pear shaped, then trumpet shaped, &c., &c. An object originally spherical, hurled against the atmosphere with such impetuosity, would, as soon as softened, become elongated.

3d. Melting. This explains the divisions that are noticed, the parting into large pieces, &c., as observed in many cases.

4th. The Burning. Which would cause the tails or trains so often remarked, the scintillations, &c.

The heat would first act upon the exterior; but finally it would extend to the interior, causing the explosions, with the loud noises, tremblings of the air, and ejection of aërolites.

The waving of the tails, mentioned in one or two cases, might be caused by the shocks of the main bodies.

The appearance of solid meteors has not been confined to *times* nor *seasons*.

The first aërolite of which we have any account is “the thunder-stone of Crete,” mentioned by Matchus, 1474 years before Christ. The first solid meteor is mentioned by Plutarch, in the 78th Olympiad. And it has been noticed by Boubée, that although for the last 3000 years they have both been of usual occurrence, yet that no aërolite has ever been found in any rock formation of an age prior to the deluge.

## OF THE THEORIES OF THE ORIGIN AND FORMATION OF SOLID METEORS.

There are fourteen theories of the origin and formation of solid meteors; seven of these suppose that the materials of which they are composed belong either to this earth or to the atmosphere. In six of these seven solid meteors are said to be *generated in the air*, and in the seventh to be *thrown therein from this earth*.

The first six theories are as follows—

1. Doctor Halley was of opinion that meteors were nothing but a stratum or flame of *inflammable vapor*, gradually raised from the earth and accumulated in an elevated region, which suddenly took fire at one end, and that the successive inflammation of the stratum, (like the inflammation of a train of gunpowder,) produced the *apparent* motion of the *meteor*. (Phil. Trans., No. 30.)

2. In Mr. Luke Howard's work on Meteorology, he ventures the opinion that hydrogen gas is capable of dissolving various bodies—even iron—and that it is naturally evolved mixed with carbon, in the gaseous state, in very large quantities, (even from every piece of stagnant water in the autumnal season.) "We have," he says, "to presume that, on occasion, it is collected in vast fields in the air, to be fired by electric explosions, or by some play of affinities in nature, of which we have not, as yet, a proper conception; and (the gases burning out) they let fall the earthy and metallic contents, precipitated and agglutinated, as we find them in the *aërolite*." A meteor of such a nature, says Mr. Howard, covering an extent of many acres in the atmosphere, (as they do,) may very well afford a brilliant light, though but slightly charged, in proportion to the mass, with solid matter. *It is the residue of the combustion, which descends.*

3. Abbate Ambrose Soldani, Professor of Mathematics in the University of Siena, was of opinion that the meteoric stones found near that place, in 1794, were *generated in the air*, by a combination of mineral substances, which had risen, "somehow or other," AS EXHALATIONS *from the earth*.

4. In the 1st v. of Silliman's Journal, p. 266, the outline of a theory of meteors is published by Doctor W. G. Reynolds, (1818.)

He says that meteors proceed from the earth; that they arise from certain combinations of its elements with heat, and that meteoric stones are the necessary result of the decompositions of these combinations. The earth (he says) presents one whole hemisphere to the sun in unerring daily succession. In the tropics the atmosphere opposes less resistance than in the temperate zones; and in both large tracts of cultivated land, summits and sides of mountains, margins of oceans, &c., present an almost naked surface to its rays. This exterior (he says) contains all the elements of the meteors. By the accumulation of the sun's rays, (which, though not intense, are steady and uniform for many hours every day,) minute portions of earthy and metallic compounds are *volatilized*, become elastic fluids, and ascend until they arrive at the media of their own density—say something more than one hundred miles—where they float at every

intermediate distance ; but, having no sensible resistance opposed to their mutual attraction, they congregate into immense volumes of highly concentrated elastic fluids, which, on exploding, exhibit all the phenomena of bursting meteors.

Their velocity he seems to attribute to the *explosion* ; but the immediate cause of the explosion he considers to be a *little obscure*. He refers it, however, to some modifications of electricity. If that is not deemed satisfactory, he refers it to *latent heat*.

He contends, that his theory is strengthened by the fact that meteors are most frequent and stupendous in *tropical* countries, and less frequent in our climate in *winter* and *spring*. Also, that they are most frequent toward autumn, and after a continuation of hot dry weather.

If (he concludes) the 104,023 part of a grain of the earth's surface is detached in twenty-four hours from a square foot, it will give ten pounds in every square thousand, which (he thinks) is abundant for all meteoric phenomena, and the loss would be only one grain per foot in 284 years.

5. Doctor Blagden,\* was of opinion that meteors were *electric phenomena*. He founded this opinion on—

1st. Their great number ; and, in treating of them under this head, he includes *shooting stars*.

2d. Their great *velocity* ; which, he contends, exceeds every thing else known except electricity.

3d. Their connection with aurora borealis ; which, he says, are well known to regard the magnetic meridian. And these meteors (he says) are observed to move in a direction nearly coincident with the same meridian. This, however, he admits applies most to the shooting stars.

The Doctor imagines that there are three distinct regions of atmosphere :

1. The lowest, or that of lightning and thunder.

2. The middle, or that of fire-balls and shooting stars, and

3. The highest, or that of the aurora borealis.

6. In a work entitled *Meteorology*, considered in its connection with Astronomy and Climate, by Patrick Murray, London, 1836, p. 121, the author contends that the larger class of globular meteors originate in the local atmosphere of this earth ; that their explosions are owing to the destruction of the equilibrium of their electric action by the repulsive force from within overcoming the attractive force on their superficies from without ; and that the meteoric stones which fall from them to the earth, is the *lava* they engender. In proof of this theory, he says that their directions, in traversing the atmosphere, correspond with that taken by the planets in their orbital courses in reference to the sun, i. e., the same direction as that of the *magnetic meridian*. For (he says) notwithstanding the *inherent* principle of movement which would seem to render them independent of the magnetic attraction of the poles of the earth, the progression of the generality, if not the entire of the globular meteors, has been

observed to be along the magnetic meridian, or from N. W. to S. E. Such (he adds) was the direction of the famous meteor of the 17th July, 1771, as observed both in France and England, (for which he cites La Lande.) Such was the direction of that which appeared in England, on 18th August, 1783, which, as the preceding, came from the N. W. and passed on to the S. E.\*

6th. John Dalton, the author of "Meteorological Observations and Essays." Manchester, 2d ed. : 1834, p. 243.

Is of opinion that most if not all the class of meteors denominated *fiery* are of ELECTRIC origin. Thunder (he says,) takes place in the lower regions of the atmosphere or amongst the clouds of one or two miles elevation. Lightning taking place in an atmosphere of great density, is vivid and dazzling in the extreme. The large *fire balls*, the bolides or small ones, and the shooting stars are found (he says) vastly more distant than the thunder; their light is less intense than lightning, and their velocity is measurable; they appear however from distant observations on the same meteor to traverse a high region of the atmosphere, probably from 50 to 80 miles elevation. The aurora borealis, he adds, exhibit a light infinitely more attenuated than the other meteors; it may be spread over one half of the hemisphere and not yield more light than the full moon; this he says arises from the extreme rarefaction of the air, which is almost tantamount to a torricellian vacuum. In another page (168,) he says, "I consider it almost beyond doubt that the *light* of the aurora borealis, as well as that of *falling stars* and the *larger meteors* is ELECTRIC *light solely*, and that there is nothing of *combustion* in any of these *phenomena*." But he considers the *beams* of the aurora borealis of a *feruginous* nature, because nothing else is known to be magnetic, and consequently there exists in the higher regions of the atmosphere an *elastic fluid*, partaking of the properties of iron or rather of *magnetic steel*, and that this *fluid* assumes the form of *cylindric* beams.

We shall now consider the preceding six theories.

If solid meteors are generated in our atmosphere, ought not the *materials* of which they are composed to be found therein? The *aërolites* that have been seen to fall from solid meteors, and which were originally component parts thereof, have been analyzed by the best chemists in Europe and America, and have been found to contain, always, iron, nickel and silix; often magnesia, lime, sulphur and manganese; and rarely a trace of chrome, cobalt, tin, copper, potash or soda. But we are not aware that *either* of these substances forms a component part of our atmosphere, or has ever been detected therein, except in solid meteors and *aërolites*. The atmosphere is composed of oxygen and nitrogen, and there are found therein carbonic acid gas, in the minute quantity of one thousand, and aqueous vapor. If there is any thing else in the atmosphere, even ammonia, (as supposed by Professor Liebig,) it must be in such small quantities as to be inappreciable, escaping detection when the search is aided by the most delicate instruments.

\* Berthelon de l'Electricité de Météorés, v. 2, p. 18.

No one has ventured to assume that these materials of which solid meteors and aërolites are formed, are *component* parts of the atmosphere, and those who contend that they are found floating therein are divided in opinion as to their *state* and *condition*. One set assert that they are incoherent *solid* particles. But this the law of specific gravity shows to be a natural impossibility. Native iron weighs more than five times as much as water, and the air of our atmosphere is 282 times lighter than water; how then can native iron remain suspended or float in the air while it (the iron) is in its state of a solid?

Professor Soldani contends that these materials are not only *in* the air, but that they have "*risen* from the earth." But how is it possible that a substance could have risen from the earth through a medium more than 4000 times lighter than itself?

The other set maintain that these materials are transformed into a gas before they are elevated. But this position is contrary to reason and experience. Before they could be raised from the surface of the earth the iron, &c. must be transformed into a gas of a specific gravity less than the atmosphere. To raise the temperature of a mass of iron to what is termed "a red-heat," requires 800° of F.'s thermometer; to raise it to "a white-heat," requires a temperature of 150° of Wedgewood's pyrometer; and it requires a still greater heat to transform it into a gas. Now whence is derived the immense degree of heat which, at the surface of the earth, is to effect this transformation? The highest temperature that a piece of metal exposed, at the surface of the earth, to a tropical sun, has ever been known to reach was less than 200° of F., which is only one-fourth the heat required to make it "red-hot." How then could it be transformed into a gas?

But suppose these constituents of solid meteors, by some unknown process, and contrary to all our experience, to have acquired this great heat at the surface of the earth and to have commenced the ascension, let us see what would be the consequences.

It is known that, for 7000 or 8000 yards, at least, the temperature of the atmosphere diminishes about one degree for about every 100 yards we proceed above the level of the ocean. Whence it follows, that the materials of the solid meteors, (the iron, &c.) which this theory supposes to have been, at the surface of the earth, transformed into a gas lighter than atmospheric air, would, in the ascent, come in contact with atmosphere gradually growing colder and colder, in proportion to the height attained, at the rate above stated. Now would not this (heated) gas continually change caloric with the constantly cooling air? and then, long before it arrived at the altitudes at which some of these solid meteors have been seen, viz. from 26 to 85 miles, would not the heat be all dissipated?—the gas retransformed into solid particles?—and these solid particles, being more than 4000 times heavier than air, would they not return again to the earth, with a velocity much greater than that with which they commenced their flight?

Again, the gas of these materials of solid meteors, the iron, &c., in order to rise in the atmosphere, must be lighter than the air; and, it

must be recollected, that the comparison above made between the weight of the air and this gas, through the medium of water, was of air *near the surface of the earth*, and not of air at the height at which these solid meteors have been seen. But the atmosphere expands and becomes lighter as you proceed from the surface of the earth toward infinite space. At the height of 1000 feet above the earth the gas would have passed  $\frac{1}{30}$  of the atmosphere; at 10,600 feet it would have passed  $\frac{1}{3}$  of the atmosphere; at 18,000 feet the gas would have passed  $\frac{1}{2}$  the atmosphere, and at the height of 28 miles, (which was the altitude of the solid meteor seen in Ohio, in 1838,) the gas would have passed  $\frac{2}{3}$  parts of the atmosphere. Now how can it be believed that iron, nickel, silex, &c. &c., can be reduced to gas so exceedingly rare as to have been lighter than the air at this last mentioned point, to say nothing of other solid meteors which have been discovered at the heights, respectively, of 42, 49, 54, and 85 miles.

If solid meteors are formed in our atmosphere, from materials derived from our earth, as these theorists suppose, how comes it that, in their mineralogical composition, they are *unlike* any other substance found, either upon its surface or within its bowels? Their principal ingredients, (as has been proven by repeated examinations of aërolites which have been seen to fall from them,) is *native iron*. They also contain *native nickel*. But these two metals are not only not found *together*, in the native state, in any other mineral compound; but the existence of native iron or native nickel, *separately*, is of very rare occurrence; the former is so much so that Mr. Thompson, one of the most able mineralogists and chemists, doubts whether it has *ever* been found in a native state, except in aërolites.

It was, principally, upon the faith of this fact, that Baron Humboldt founded his opinion that solid meteors did not belong to our atmosphere.

But supposing, (for the sake of argument only,) that the constituents of which these solid meteors are formed were in the atmosphere, in either of the states above supposed, let us next inquire how they could be retransformed into solids of the immense bulk and weight of solid meteors, and yet remain in the air.

The solid meteor seen in England in 1758 was variously estimated by different beholders, at from  $\frac{1}{2}$  to  $\frac{2}{3}$  of a mile in diameter. The one seen in Ohio in 1838 had a diameter of  $\frac{1}{4}$  of a mile, &c. Besides, the immense light which solid meteors dispense, illuminating the country around to a great distance, and throwing shadows, although the sun is shining, are proofs that their dimensions are exceedingly great. But the only rational explanation of the consolidation of particles of matter so as to form congeries of particles, is the attraction of the incoherent atoms for each other, according to that law which says that every particle of matter in the universe attracts every other particle, with a force directly proportioned to the mass of the attracting particle and inversely to the square of the distances between them.\* Now this explanation fails

\* Herschel.

in the present case, since it is impossible to conceive why the previously incoherent particles, as soon as they have united together and the congeries have acquired a weight greater than that of the atmosphere, do not gravitate to this earth, as takes place with rain, hail and snow ; rather than, contrary to all reasonable expectation from the law above quoted, that the congeries should still remain suspended in a medium more than 4000 times lighter than themselves, until they, by the addition of new atoms, attain the enormous sizes and weights of many of these solid meteors. Calculating the one seen in Ohio at the diameter above stated, it must have weighed 167,736,662 tons.

Before, therefore, we can admit this theory of solid meteors being formed in our atmosphere, we must believe that a fundamental and universal law of nature has, in their cases, been abrogated, or at least suspended.

If solid meteors are formed in our atmosphere, whence do they derive their initial motion, their velocity, and their directions ?

If solid meteors originate in the coalescence of previous incoherent atoms of iron, &c., previously floating in the air, the action of these atoms upon all sides of the nucleus of the congeries would, most probably, be *uniform*, and the consequence would be *a state of rest* to the newly formed body.

But supposing the action of the atoms not to be uniform, and the newly formed body to be thereby set in motion, still how are we to account for their *velocity* ? Solid meteors have a velocity of 30 miles in a second, or 1,800 miles in a minute. That they did not receive this velocity from the air is certain, for it is an axiom that "no body can impart to another a velocity greater than it possesses itself;" and the greatest velocity of the air in the most violent hurricane ever known was less than 3 miles in a minute.

7. Nor is it possible to reconcile the theory of solid meteors being formed in the air, with their *horizontal direction*.

If solid meteors are generated in our atmosphere, the materials must have emanated from the earth ; and, in that case, according to the general *law of compensation*, which pervades all nature, they should gravitate to this earth again.

Besides, a solid substance raised to a great height, or formed at such an elevation, when left to itself would rapidly descend ; as is witnessed in the cases of the aërolites ejected by solid meteors. Whereas, the *direction* of the last mentioned bodies is parallel to our horizon, or nearly so ; a deviation from the well known laws of Nature, for which the theory we are examining furnishes no explanation.

8. This theory of solid meteors being generated in our atmosphere does not account for the highly heated state to which these bodies have been known to have arrived. Those who maintain that they are formed from previously incoherent atoms of solid matters floating in the air, attempt *no* explanation whatever of the heat ; and those who contend that the materials are retransformed from a gas, are little more successful. They suggest that upon the taking place of the chemical change from a gas to a solid, caloric would be

evolved; but, it must be recollected, that on the happening of such an event, each particle of the incoherent constituents would be *heated separately*, and hence, when consolidation took place, the meteor would form a mass of fire. Whereas many are the instances of their having been seen red-hot on the surface, and a little below it, and yet, when they have exploded, the interior has appeared to be black and unchanged by heat. A proof, as we respectfully submit, that the heat is communicated to the main body of the solid meteor after it has been formed, and not to the constituent particles in the way this theory requires us to imagine. No one has ever seen the incandescent incoherent particles approaching each other to form a mass, but many have witnessed the incandescent fragments thrown from the heated surface of a solid meteor.

And lastly, this coalescence of heated particles to form a mass, fails to account for the explosions which are so frequently witnessed, and the noise of which is so often heard—phenomena that are rationally accounted for upon the principles we have advanced.

9. It remains only to examine the theory of Doctor Reynolds, who maintains that solid meteors are formed in our atmosphere from certain combinations of constituents of this earth, *volatilized by the sun*. He seems to entertain the opinion that the slow but constant power which the sun possesses of transforming water into vapor is sufficient to volatilize *mineral* and *earthy* substances. That the sun, of itself, possesses no such power, we think has been herein before satisfactorily shown; and that there is no reason for believing that water or its vapor, however long its action confers volatility, even in the slightest degree, upon metals or earths, we are authorized to presume from a series of very interesting experiments, made by Mr. Faraday, Director of the Laboratory of the Royal Institution of G. B., the particulars of which are detailed in a paper published in the first volume of the Journal of that Institution, page 70, to which those who would pursue this study are respectfully referred.

From all which it is contended that solid meteors are not generated in our atmosphere.

The seventh theory of the origin and formation of solid meteors supposes them to have been thrown into the air from this earth. The advocates of this theory are divided into two parties.

1st. Those who contend for their being thrown from volcanoes of this earth generally.

2d. Those who favor the notion that they are thrown from volcanoes situated in the polar regions of our planet.

Doctor Brewster believes that meteoric stones are minerals, in their primitive state, which are ejected from the interior of our globe by volcanoes situated in the polar regions, which produce at the same time (he thinks) phenomena of the northern lights.\*

La Grange, the most celebrated mathematician of modern times, agreed with Brewster in this opinion, and has made a calculation of the force necessary to project them.

But it has been answered, (Prof. J. Day,) "That the substances

\* Ed. Phil. Jour.

which are known to be thrown from terrestrial volcanoes are all of a different kind from these stones.

“That *aërolites* have fallen hundreds and thousands of miles from any volcano. That it is next to impossible that they should have been carried thus far, by any force which could be applied to them near the surface of the earth. The resistance of the air is so great, that it will not suffer the motion of a body in the lower regions of the atmosphere to exceed a certain limited rate. The greatest possible velocity that can be given to a cannon ball will be reduced almost immediately to eleven or twelve hundred feet in a second. A large body would be retarded in a less degree; still the resistance would be so great as soon to bring it to the ground. It requires an initial velocity greater than that of sound to carry a cannon ball only three or four miles. Is it not then incredible that a body a quarter of a mile in diameter should be thrown from a volcano with a force sufficient to carry it hundreds or thousands of miles; and that, after having gone that distance, it should still retain a velocity such as these meteors possess?”

“But what is considered as decisive of this point is, that the main bodies of meteors never do come to the earth. It is a law of matter, that if it is projected from another body in any way whatever, if acted upon, subsequently, by no other force but that of attraction, it must inevitably return again to the body from which it was projected.”

Besides, these meteors contain native iron, and no iron, except in a state of oxide, has ever been found among volcanic productions. They also contain nickel and chrome, both very rare metals, the former never found at the surface of this earth except in *aërolites*.

Mr. Edward King, concerning the meteoric stones that fell at Siena, in Italy, says, that the space of ground within which the stones fell, was from three to four miles; that the phenomena took place the very day after the great eruption of Vesuvius, which is distant 200 miles south. That the cloud came from the north about 13 to 18 hours after the eruption.

Mr. King then briefly mentions his former observations on the formation of stones and rocks by fire and water, and proceeds to say that an immense cloud of ashes, mixed with pyritical dust, and with numerous particles of iron, having been projected from Vesuvius to a most prodigious height, became afterwards condensed in its descent, took fire, both of itself as well as by means of the electric fluid it contained; that it produced many explosions, melted the pyritical, metallic and argillaceous particles of which the ashes were composed, and by this means a sudden crystallization and consolidation of those particles took place, which formed the stones of various sizes that fell to the ground, but did not harden the clayey ashes so rapidly as the metallic particles crystallized, and therefore gave an opportunity for impressions to be made on the surface of some of the stones as they fell, by means of the impinging of the others.\*

To this it is answered that *no* theory to account for the stones

\* King on *Aërolites*, 1796.

that fell at Siena can be well founded unless it explains meteoric stones in general, and all the meteors from which they have fallen. This theory, therefore, is liable to all the objections that have been already mentioned.

Philosophers who admit that solid meteors do *not* belong to our atmosphere or earth, are divided into seven sets.

1st, and 8th of the whole. Those who contend that they are thrown from volcanoes in the moon—among whom are Hutton and La Place.

2d, and 9th of the whole. These think that they may proceed from the tail of a comet—at the head of which theory was Newton's.

3d, and 10th of the whole. Those who contended that they are terrestrial comets—where we find Professors Clapp and Day, and Cavallo.

4th, and 11th of the whole. Those who imagine that they are solids that have been floating in space from the beginning, viz. Professor Chaladni, Franklin, and Rittenhouse.

5th, and 12th of the whole. That they are the fragments of an exploded planet—Ferguson, Olbers, &c.

6th, and 13th of the whole. That they belong to a zone through which this earth passes annually—Mons. Quetelet.

7th, and 14th of the whole. That they are the fragments of an exploded comet—Mons. Boubée.

8. Some Philosophers (among whom was the celebrated La Place) have imagined that meteoric stones have been ejected by volcanoes in the moon.

It is said that there is a certain point between this earth and the moon in which, if a body were placed, the attraction of the earth and moon would be *equal*. This point is calculated to be 24,000 miles from the moon's centre, and about one tenth of her distance from the earth.\* Now, it is said, that if the moon and the earth were both at rest, and a body were sent directly from the former to the latter, it would strike it; but an object thrown from the moon would partake of its motions, and the line pursued by the object would be a *curve*; and it, being attracted by the earth, would revolve round it.†

But it is answered, 1st. That it has never been proven that there are any volcanoes in the moon. Ferguson is of opinion that the evidence adduced is entirely unsatisfactory.

2d. That no theory of *aërolites* can be admitted that does not account for the meteors from which they emanate. Now, the altitudes of the mountains of the moon are altogether too insignificant to admit, for a moment, that they could cast up such immense bodies as meteors. According to Herschel, the moon's mountains do not exceed half a mile, which would make them but little larger than some of the meteors that have appeared, and less than others.

3d. The velocities of these meteors, and that which would be necessary to bring them to the required point, do not agree. We

\* Sir John Herschel says, that the centre of gravity of the earth and moon lies always within the surface of the earth, p. 273.

† Dr. Hutton advocated this theory. See Reese's Enc. Title, "Balls of Fire."

are told\* that the velocity with which a body must be thrown from a lunar volcano, to reach the point of equal attraction, is about 90 miles in a minute. Solid meteors have a velocity of 1,800 miles in a minute.

4th. As it is required by this theory, not only that the direction should be to this earth, but that the velocity of the matter ejected should be *just* sufficient to carry it beyond the point of mutual attraction, it is not probable that of 1,000 masses thrown at random from the moon, one would have both the *direction* and velocity required. To account, therefore, for all the meteors that have been seen, and those from which aërolites have fallen, when not seen, would require that the moon, during the last 1,800 or 2,000 years, should have thrown off hundreds of thousands of mountains,† which would have been sufficient to have affected her own gravity and motion.‡

5th. The heat that would be required to throw such a mass as one of these meteors to the required distance, would be sufficient to liquefy, if not transform it into a gas.

9. Sir Isaac Newton thought that the matter of the *exhalation* of which the tails of comets are composed, might fall, by its gravity, into the atmosphere of any planet, but more especially into that of the earth, be condensed there, and give rise to all sorts of chemical reactions, and a thousand new combinations, and among the rest, of meteors. He also believed what were called the *exhausted* or *extinguished* stars, again become conspicuous, and suddenly recover their former brilliancy, when comets, by falling into them, furnish them with fresh combustible matter.§ This theory is based upon the supposition that solid meteors are gaseous, whereas we have shown that they are solids.

10. Professor, the Rev. Thos. Clapp, of Yale College, in a MS. found among his papers after his death, and since published, supposes that these meteors may be *solid bodies* revolving round the earth in eccentric orbits, as the comets revolve around the sun, their size and revolutions being proportioned to the size of their primitive body;|| that now and then some of them come so near as to fall upon it; that by the *friction* of the *air* they are heated, and that they are highly electrified. That the electricity is discharged with a violent report, after which they move off with great velocity, and are soon out of sight.

The learned Cavallo explains the theory of Mr. Clapp, thus—“Imagine,” he says, “that a revolving body moves round the earth.

\* By La Place.

† The diameter of the moon is only 2,160 miles, (Herschel;) the bulk about one forty-ninth of this earth, (do.)

‡ It is replied to this, that there is reason to believe that the moon is nearer to the earth now than she was formerly, her periodical month being shorter than it was in former ages; for the astronomical tables which, in the present age, show the times of solar and lunar eclipses to great precision, do not answer so well for very ancient eclipses.

But, it is rejoined, that M. De la Place has shown that this acceleration in the moon's motion arises from a diminution in the eccentricity of the earth's orbit; that it is generated by the mutual action of the planets, and is balanced by irregularities of an equal and opposite kind.

§ Wonders of the Heavens, 208.

|| Before the orbits of comets were understood, the ancients considered them all as *Meteors*.

with a velocity somewhat like that of the moon, or of the earth in its orbit ; also, suppose that the attractive force, in proportion to the centrifugal, is rather stronger than *that* which is required to keep the revolving body in the same immutable orbit ; and that, consequently, the said body must move in a sort of *spiral*, coming continually nearer and nearer to the earth. Now, when this body comes within a certain part, however rare, of the atmosphere, with its immense velocity, the *friction* it suffers may possibly heat it to a degree of incandescence, checking, at the same time, its centrifugal force, which, consequently, increases the gravitating or attractive power." The great heat which the body acquires in consequence of the *friction*, produces, he says, two natural effects. In the first place it partly melts or vitrifies the external surface which forms the common black crust of the body ; and, secondly, by expanding, unequally, the parts of the body causes it to break, with explosion, in the same manner as stones often do in a common fire.

Professor Day, also, in support of this theory observes, that "a body moving near the earth with a velocity less than 300 miles a minute, must fall to its surface by the power of gravitation. If it moves in a direction parallel to the horizon, more than 430 miles in a minute, it will fly off in the curve of a hyperbole, and will never return, unless disturbed in its motion by some other body besides the earth. Between these two velocities, he says, it will revolve in an ellipsis returning in regular periods.

Now the velocities of these meteors he supposes to be something more than 300 miles in a minute, and consequently he believes these meteors to be terrestrial comets.

It is answered to this theory—

1. That they have never been seen revolving around this earth in either way above mentioned.

2. That with the velocity they have they cannot move round this earth.

3. That with the spiral motion ascribed to them by Cavallo the main body must eventually come to the earth, which never happens.

4. They never could have acquired their *heat* by *friction* as contended.

11. Professor Chaladni, of Wittenberg, gives the following as his opinion :—

These meteors (he says) are *dense matters, accumulated in small masses*, but *without being in immediate connection with the larger planetary bodies* ; that they are *dispensed throughout infinite space* ; and, being impelled, either by *some projecting power* (what it is he does not explain) or attraction, they continue to move until they approach the earth, or some other body ; when, being overcome by their attractive force, they immediately *fall down*. By their exceeding great velocity, still *increased* by the *attraction* of the earth, and the violent *friction of the atmosphere* (he supposes) a strong electricity and heat must necessarily be excited, by which means they are reduced to a flaming and melted condition ; and that great quantities of vapor and different kinds of gases are thus disengaged,

which distend the liquid mass to a monstrous size, until at length it bursts.\*

Franklin and Rittenhouse, it is said, inclined to this theory.†

12. Ferguson, after giving his reasons for believing that the four small planets, Juno, Pallas, Ceres and Vesta once composed a single planet, which has exploded,‡ proceeds as follows:

“Let us now consider the other phenomena which might be supposed to accompany this great revulsion.

“When the cohesion of the planet was overcome by the action of the explosive force, a number of little fragments, detached along with the greater masses, would, on account of their smallness, be projected with very great velocity; and being thrown beyond the attraction of the larger fragments, might fall towards the earth when Mars happened to be in the remote part of his orbit. The central parts of the original planet being kept in a state of high compression by the superincumbent weight, and this compressing force being removed by the destruction of the body, a number of lesser fragments might be detached from the larger masses, by a force similar to the first. These fragments will evidently be thrown off with the greatest velocity, and will always be separated from those parts which formed the central portions of the primitive planet. The detached fragments, therefore, which are projected beyond the attraction of the larger masses, must always have been torn from the *central* parts of the original body; and it is capable of demonstration, that the *superficial* or *stratified* parts of the planet could never be projected from the fragments which they accompany.

“When the portions which are thus detached arrive within the sphere of the earth’s attraction, they may revolve round that body at different distances, and may fall upon its surface, in consequence of a diminution of their centrifugal force; or being struck by the electric fluid, they may be precipitated on the earth, and exhibit all those phenomena which usually accompany the descent of meteoric stones. Hence we perceive the reason why the fall of these bodies is sometimes attended with explosions and sometimes not; and why they generally fall *obliquely*, and sometimes horizontally, a direction they never could assume if they descended from a state of rest in the at-

\* London Philosophical Mag., vol. 2, p. 1.

† See Reese’s Encyclopedia. Title, “Balls of Fire.”

‡ It was the late Prof. Bode, of Berlin, and not Doctor Olbers, of Bremen, (as some suppose,) who first surmised that a planet might exist between Mars and Jupiter. The first of the ultra-zodiacal planets that was discovered was Ceres, at Palermo, in Sicily, on the 1st Jan. 1801, by M. Piazzi; Pallas was discovered at Bremen, in Lower Saxony, on the 28th March, 1802, by Dr. Olbers; Juno, 1st September, 1804, at Lilienthal Observatory, near Bremen, by Mr. Harding; and Vesta on 29th March, 1807, by Dr. Olbers. It was after the discovery of the first three of these small planets that Dr. Olbers suggested that they might be merely fragments of a larger planet which had been burst asunder, and that several more might be found between the orbits of Mars and Jupiter. Ferguson originated the idea that the small fragments of the disrupted planet furnished meteoric stones.(a)

Sir John Herschel, in his recent Treatise upon Astronomy, observes—“It has been conjectured that the ultra-zodiacal planets are fragments of some greater planet, which formerly circulated in that interval, but has been blown to atoms by an explosion; and that some more such fragments exist, and may hereafter be discovered. This may serve as a specimen of the *dreams* in which astronomers, like other speculators, occasionally and harmlessly indulge.”

(a) Ferguson’s Astronomy, vol. 2, p. 493, where he announces this as a theory of his own.

mosphere, or had been projected from volcanoes on the surface of the earth."

M. De la Grange, a most celebrated mathematician, maintained that meteoric stones are unchanged minerals from the interior of a planet; and he has investigated formulæ for computing the velocity with which the fragments of a bursted planet must be projected, in order to move in elliptical parabolic, or hyperbolic orbits. Assuming the initial velocity of a cannon ball, at 1,400 French feet persecond, he has shown that in the case of a planet situated beyond the orbit of Uranus, a velocity twelve or fifteen times greater than that of a cannon ball would be sufficient to make the fragments move in an elliptical or parabolic orbit, whatever be their dimensions, and the direction in which they are projected.\*

This theory is exceedingly ingenious, but there is an answer to it which would appear to be conclusive. If a large planet, situate between Mars and Jupiter, has been burst asunder, as above supposed, no fragments thereof could ever have come within sight of this earth, except those whose original courses were in that direction. And then, when it is considered that the forces with which these fragments were projected were equal, and that they had to travel over equal spaces, they ought to have arrived within sight of this earth in equal times; whereas the periods of their apparitions are scattered over two thousand years. If the solid meteor which was seen in the 78th Olympiad was a fragment of this disrupted planet, its explosion must have taken place antecedently to that period; how then can the advocates of this theory account for the detention or stoppage, in transitu, of those fragments which have made their successive appearance, down to the present day?

13. As M. Quetelet, Director of the Royal Observatory at Brussels, says, that the greatest number of the existing savans believe in the *identity of meteors and shooting stars*, it may not be amiss to quote what that learned gentleman has said, as regards the *shooting stars*:

"Ainsi se confirme de plus en plus, (comme le remarquait M. Arago,) l'existence d'une *zone* composée de millions de petits corps, dont les orbites rencontrent le plan de l'écliptique, vers le point que la terre va occuper tous les ans du 11 au 13 Novembre, c'est (dit il) un *nouveau monde planétaire*, qui commence à se révéler a nous." —12 vol. of the Mem. of the Acad. Royale de Brussels, 3.

In the 1st vol. of the Edin. Phil. Jour., 223, is a list of meteoric stones that have fallen from the earliest time to the year 1819, from which it appears—

Cases reported, - - - - - 177

Of cases where the month is mentioned: there fell in January, 12; February, 6; March, 10; April, 11; May, 14; June, 13; July, 13; August, 10; September, 10; October, 9; November, 8; December, 5.

14. Mons. Boubée is of opinion that solid meteors are the frag-

\* 1 v. Ed. Phil. Jour., 222.

ments of a comet which, he supposes, was driven against this earth, and caused the Deluge mentioned in Sacred History. But, had a comet ever come in contact with this earth, they never more would have separated; once together, and both these bodies would have attained a position of stable equilibrium, which forever after would have held them indissoluble.

Doctor Franklin suggested the idea that the great dry fog of 1783 was caused by an immense bolide, (solid meteor,) which, in penetrating our atmosphere, had been become half inflamed, the torrents of smoke formed by its imperfect combustions at first lodging in the highest regions of the air, and afterward spreading in all directions, and through all the atmospheric strata, by the action of the ordinary winds, &c.

M. Arago, after noticing the above suggestion, observes, "The *aërolites* that fall occasionally to the earth, are sometimes very compact metallic masses. Several have been found of a spongy texture. Sometimes they descend in dust, either alone or mixed with rain. Suppose this dust brought to another degree of firmness; let us in idea reduce them to impalpable modicules, so light as to descend with difficulty through the air very slowly, and we shall have a hypothesis explanatory of the appearance of dry fogs."\*

Having given the reason for dissenting from all the theories of the origin of solid meteors, it is very natural that I should be called upon for my own. I HAVE NONE! Sufficient facts have not yet been collected in relation to the natural history of these extraordinary objects whereon to find an *hypothesis*. The public mind has however been awakened, astronomers and philosophers are on the alert, and the time may not be far off when their origin and formation may be pronounced upon with more certainty by the learned. In the mean time I have no objection to impart what has struck my mind as a more *possible supposition* than any theory of their origin yet promulgated. I flatter myself that it will not be illiberally received.

Solid meteors *may, possibly*, emanate from the *sun*. That they do not proceed from this earth, nor are generated in the atmosphere, I claim to have proved; we must, therefore, seek for their origin *beyond our atmosphere*. But in so doing we are met with this prominent fact, viz. that while on the one hand the combination of *native iron and native nickel* in *arëolites*, and consequently in these meteors when they do not occur any where on this earth, is one of the strongest proofs that they do not belong to our *planet*; the circumstance that there is not found in them *a single new mineral*, seems to proclaim that they *belong to our SYSTEM of worlds*. They contain iron, nickel, manganese, chrome, cobalt, tin, copper, silex, lime, magnesia, alumine, potash, soda, sulphur, phosphorus = 15, which are all found on this earth or beneath its surface.

In seeking for the origin of solid meteors then, beyond our atmosphere, but within our system, where shall we look but toward the *sun*?

\* Comet, p. 17.

Their enormous *size*, while it forbids alike ascribing them to the moon or this earth, forms no objection to their emanating from the sun, for that great luminary has the *vast* diameter of 882,000 miles, and contains 354,936 times the mass or quantity of ponderable matter as this earth. It might therefore well spare (if I may be allowed the expression,) the substance to be thrown from it which makes up the bulk and weight of these meteors; especially if (as some astronomers suppose,) comets (of which hundreds have been seen and thousands supposed to exist,) end their eccentric career by falling into the sun, thereby making up for any deficiency they may experience by throwing off these solid meteors. Besides, if solid meteors emanate from the sun, and they meet with no obstructing force, they must eventually obey the law of dynamics and return themselves to the sun again.

2. The great altitude at which solid meteors have been seen, pursuing their lineal courses, favors this view of their origin. They have been seen 10 and 20 miles beyond our atmosphere, as indicated by the barometer and the duration of twilight.

3. There are some facts on record that deserve our notice. Monsieur Messier in 1777, at noon day, saw a prodigious number of black spots pass over the sun.\*

1777, 17th June, at noon, the astronomer M. Messier, in 5 minutes saw a prodigious number of black globules pass over the sun.

Mr. Arago, in allusion to this case, inquires "why they may not have been *aërolites*?"

The sub-prefect of Embrun, the 7th of Sept. 1820, saw balls of fire of a diameter equal to that of the largest stars, projected in various directions from the upper hemisphere of the sun with an incalculable velocity; and although this velocity did appear to be the same in all, yet they did not all attain the same distance. They were projected at unequal and very short intervals; several were projected at once, but always diverging from one another. Some of them described a right line and were lost in the distance; some described a parabolic line and were in like manner extinguished. Others again, after having removed to a certain distance in a direct line, retrograded upon the same line, and seemed to enter, still luminous, into the sun, &c. &c.

The ground of this magnificent picture was a sky blue, somewhat tinged with brown.†

Why may not these have been *aërolites*?

Prof. Hamstein, in 1825, at 11 A. M., saw passing in the field of his telescope a *luminous point* brighter than a star, which may have been a solid meteor similar to those seen by the sub-prefect of Embrun.

And it is more than probable that the object described by Seneca as having been seen sixty years before the Christian era, which was very near the sun, was a solid meteor. It was taken for a comet.

4. If solid meteors emanate from the sun, then is their initial

\* Vol. 12 of the Memoirs of the R. A. of Brussels.

† Annales Chimie, Oct. 1825.

motion accounted for; so also is their *velocity*. Their velocity, says the sub-prefect of Embrum, was *incalculably great*.

If it shall hereafter be decided that solid meteors do emanate from the sun, we will be enabled to infer,

1st. That the sun is composed of the native metals, and the metallic bases of the earths and alkalies.

2d. That the sun has no atmosphere.

3d. It will become probable that all the planets of our system are composed of the same mineralogical materials.

Having submitted my views, the whole subject is left to the impartial decision of the learned throughout the world.